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THE MACHINE TOOL INDUSTRY IN ALGERIA AND TUNISIA*

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* The views expressed in this paper are those of the authors and do not necessarily reflect the views of the Secretariat of UNIDO. Mention in the text of firm names and commercial products does not imply the endorsement of UNIDO. This document has not been edited.

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INTRODUCTION

After a brief introduction to the economic and industrial development of Algeria and Tunisia, the study describes the Algerian machine tool industry and analyses the market and the machine tool reserves in Tunisia. After analysing the trends in the machine tool industry in the two countries, the study concludes by presenting three variants for the future development of the machine tool industry in Algeria and some conclusions on the diffusion of numerically controlled machine tools in Tunisia.

I. ECONOMIC AND INDUSTRIAL DEVELOPMENT IN ALGERIA AND TUNISIA

Algeria (2.8 million km^2) and Tunisia (164,000 km^2) are two neighbouring countries in North Africa with populations, respectively, of 25 million and 8 million. The GNP per inhabitant is $US 1,180 (in 1987 dollars) in Tunisia and $US 2,680 in Algeria. The manufacturing sector provides 15 per cent of the GDP in Tunisia and 12 per cent in Algeria, and 61 per cent and 1 per cent, respectively, of the exports.

1.1 Algeria

The GNP per inhabitant is $US 2,680, and it grew at a mean rate of 3.2 per cent between 1965 and 1987.

1.1.1 An overview of the economic development

The 1960s was both a capital goods intensive and extensive phase and a decade of industrial apprenticeship. Production capacities, other than hydrocarbons, water and energy, were stepped up by a factor of 1.5, i.e. the growth rate was 14.9 per cent. The iron and steel, metallurgical and electrical industries (ISMEI) underwent an increase in capacity by a factor of 1.7, or a growth rate of 19 per cent per year.

Industrial production is carried out by national companies, local communities and the private sector. During the period 1969-1978, it is to be noted that:

- National company output more than doubled and those companies working in the ISMEI increased their production by 27 per cent per year;
- The production of local community enterprises rose at a rate of 10 per cent per year;
- The private sector recorded a growth of 7.2 per cent per year and 13.4 per cent in the case of the ISMEI.

During the period from 1980 to 1984 the high level of export income was maintained, despite the erosion in trade from 1982 onwards. Stabilization of the investment rate was instrumental in satisfying the internal demand. The country's economic policy during this period was geared to improvement of productivity in the industrial and agricultural sector.

The growth of the GDP remained high, at about 4.5 per cent, and the investments made during the previous decade helped to reduce imports in certain sectors, while the planning of imports, though still strict, became more flexible.

The period from 1985 to 1989 (second five-year plan) was one of economic crisis without precedent since Independence. Indeed, imports dropped by 34 per cent in real terms as compared with 1984, while over the same period the GDP rose by 1.8 per cent and exports by 9.5 per cent. Investments fell more heavily than the consumption by households, and the employment market fell clearly back (300,000 more unemployed persons in three years, basically young people) and the purchasing power of low incomes deteriorated.

A decrease in the price of oil products and an increase in the rate of exchange for the Algerian dinar brought Algeria a major challenge, namely the pursuit of fast development while allowing for the requirements of external constraints.

In face of this situation the authorities drew up for 1989 a plan aimed at establishing conditions for a return to a growth rate of the order of 5 per cent and reinvestment in accordance with priority for projects likely in the short term to generate export revenue and foreign currency gains, and to gradually replace imports and speed up national economic integration.

1.1.2 Structure of industry

In 1987 the industrial sector employed nearly 534,000 wage-earners, of whom nearly 100,000 were working in private industry and the rest in the public sector, with about 23,450 of them working in local community enterprises.

Per sector of activity the greatest number of employed was concentrated in the iron and steel, metallurgical, engineering and electrical industries (ISMEEI), with 143,581 wage-earners (see table 1). The least concentration of wage-earners is to be found in the various industries, with 8,111 work-places.

It is also in the ISMEI and chemicals that the development compared with 1984 was strongest, with an increase of 22 per cent in employed persons, followed by the leather industry with 17.4 per cent and the water and energy sector, with nearly 15 per cent. Conversely, the textile industry underwent a loss of jobs of the order of 4.7 per cent, compared with 1984, together with the wood, cork, paper and printing industry, which showed a decrease of 1,845 work-places.

Industrial trade

The rate of cover of industrial trade (ratio between exports and imports) was 3.1 per cent in 1987. Penetration of the domestic market by imports dropped from 31 per cent in 1983 to 17.8 per cent in 1987 on account of the decline in imports.

Investments

Gross accumulation of fixed funds for the year 1987 (16,999.4 million dinars) showed a marked decrease of 5.7 per cent, as against 1986. Compared with the value added, this gives us an investment rate for Algerian industrial enterprises as a whole (all juridical sectors taken together) of 19.7 per cent. For information purposes, the investment rate in 1979 for national industrial companies as a whole was 59.1 per cent.

The drop in investments was accompanied by a parallel decrease in the demand for machine tools.

Table 1

ALGERIA

Trends in employment and number of enterprises for industry as a whole
Distribution by sector of activity - Years: 1984 and 1987

Number of activity sector	Title	Persons employed			Number of enterprises		
		1984	1987	Trend (%)	1984	1987	Trend (%)
02	Water and energy	23 994	27 495	14.6	14	13	-7.1
03	Hydrocarbons	56 564	60 606	7.1	2	2	0
05	Mines and quarries	14 593	12 441	-14.7	256	255	-0.4
06	ISMEEI	117 125	143 581	21.8	1 089	1 553	42.6
07	Building materials	44 111	46 032	4.4	1 470	1 478	0.5
09	Chemicals, rubber and plastics	23 257	28 368	22.0	259	361	39.4
10	Agro-food industry	82 041	88 340	7.7	4 418	4 699	6.4
11	Textile, hosiery and clothing industry	67 804	64 585	-4.7	3 518	2 803	-20.3
12	Leather and footwear industry	14 719	17 281	17.4	854	772	-9.6
13	Wood, cork, paper and printing industry	38 627	36 782	-4.8	2 218	2 529	14.0
14	Various industries	7 232	8 111	12.2	507	806	59.0
	TOTAL	490 067	533 622	8.8	14 605	15 271	4.6

Table 2

ALGERIA

Trends for industry as a whole: Production and operational accounts

Current prices (In millions of Algerian dinars)

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Production accounts											
Gross production	38 603.6	40 567.8	50 177.2	56 270.4	63 997.3	84 709.1	112 637.9	137 807.9	134 806.0	158 718.0	170 197.9
Production consumption	14 829.1	19 105.5	23 088.4	24 201.7	28 595.0	37 604.4	45 472.5	59 907.0	54 702.7	72 243.4	73 738.4
Gross value added	23 774.5	21 462.3	27 088.8	32 068.7	35 402.3	47 104.7	67 165.4	77 900.9	80 103.3	87 474.6	96 459.5
Operational accounts											
Gross value added	23 774.5	21 462.3	27 088.8	32 068.7	34 402.3	47 104.7	67 165.4	77 900.9	80 103.3	87 474.6	96 459.5
Payment of salaries	3 363.1	4 038.8	4 909.8	5 584.6	6 972.0	8 765.4	11 431.6	12 702.9	14 462.8	17 518.4	18 609.6
Production-linked taxes	4 861.6	5 414.6	6 524.1	7 647.1	7 953.4	11 179.8	15 009.2	17 227.7	17 462.3	16 765.7	19 011.0
Net operational surplus	13 979.4	10 064.8	13 343.0	16 313.0	17 804.7	22 587.3	34 205.5	40 073.4	38 593.1	41 832.0	48 693.8

N.B.: The production and operational accounts for 1985 and 1986 are in process of preparation.

Source: NSO.

1.2 Tunisia

The GNP per inhabitant is $US 1,180 (1987 dollars) in Tunisia and between 1965 and 1987 it grew at an average rate of 3.6 per cent.

1.2.1 Overview of economic development

The investment effort made during the first development decade 1962-1971, which was mainly initiated by the public sector (68 per cent), was first and foremost geared to infrastructural projects with deferred productivity. The growth rate of the gross domestic product over that period was 4.6 per cent per year, given a population growth of 2.5 per cent per year, and the creation of jobs hardly averaged 13,200 per year, representing only 30 per cent of the additional demand for employment.

Starting in the 1970s there was a clear-cut reversal in favour of private initiative, which now covers almost 44 per cent of the overall investment effort. This trend also covered the promotion of small and medium-size projects which have a fast output and create jobs; this has led to an important change in the economic structures and to the development of the manufacturing industry and tourism. Thus the growth rate of the gross domestic product improved and during the second development decade 1972-1981 attained an average of 7.1 per cent per year. Industrial growth speeded up (9.8 per cent per year instead of 8.3 per cent between 1962 and 1971).

At the beginning of the 1980s, there were, however, signs of a falling off in the GDP growth rate, which averaged 2.9 per cent per year during the sixth development plan (1982-1986). Industrial growth progressed at a rate of 5.4 per cent per year.

Despite the priority accorded to the private sector, which was the origin of 45 per cent of the total investment during that period, the creation of new jobs fell below the additional requirements: 40,000 on average per year given a demand of 47,000 per year.

In order to avoid a recession it was necessary to adopt a structural adjustment programme (SAP) at the time when the seventh development plan for the period 1987 to 1991 was being worked out.

It has two main aims:

- A reduction in the macroeconomic imbalances;
- An improvement in the effectiveness of the production apparatus by a progressive liberalization of the economy, touching on prices, investments, foreign trade and interest rates. The restructuring of public enterprises and reforms in taxation also represent important aspects of the programme.

After three years' application, the programme is showing some positive results:

- An upswing in investment which began in 1989 after a continuing downtrend since 1984;
- An increase in exports at a rate higher than for imports (23.8 per cent as against 19 per cent at current prices);
- Consolidation of foreign currency reserves.

Table 3

Trends in some of the global indicators for the Tunisian economy

	First decade 1962-1971	Second decade 1972-1981	Sixth plan 1982-1986	Period 1987-1989
Growth rate of GDP at current prices	4.6%	7.1%	2.9%	3.5%
Industrial growth	8.3%	9.8%	5.4%	6.3%
Investment in millions of Tunisian dinars, of which:	1 310	6 350	8 900	5 300
Share of public sector	68%	56%	55%	51%
Share of private sector	32%	44%	45%	49%
Investment rate	22.4%	28%	29%	20.3%
Creation of jobs	132	400	200	121
Percentage of additional demand for employment	37%	85%	63%	58%

1.2.2 Industry

Tunisian industry employs 260,000 wage-earners and during the seventh plan it will be expected to provide for 27 per cent of the new jobs (or 67,000).

Industrial trade

Industrial exports rose from 50 million dinars to 480 million between 1971 and 1981, after which they tripled in the course of the 1980s and reached 1,423 million.

Investments

The manufacturing sector has seen an increase in investments: 11 per cent of the global figure during the first decade, 17.7 per cent during the second, and 16.4 per cent is expected during the seventh plan. The distribution foreseen in the seventh plan provides for the rapid growth of investments in the mechanical and electrical engineering industries, textiles and leather, and a downtrend in the chemical and building materials industries.

ISMEEI

This sector covers in actual fact the engineering, metallurgical, electrical and electronics industries - EMEEI. In Tunisia it was started up at the beginning of the 1960s by the installation of a modest iron and steel plant, cast iron and steel mill, several assembly lines for vehicles and electromechanical appliances, electric motors and transformers, and by an increase in the number of metal construction units.

Today the sector groups together some 400 enterprises producing a range of different articles, from the manufacture of products requiring only simple technology (machine welding) to more sophisticated equipment (capital goods such as woodworking machines and diesel motors). In overall terms, the place of this sector in the manufacturing industries and national economy remains modest. Over the period from 1973 to 1988 the value added for the sector represented about 14 per cent of that of the manufacturing industries and 14.5 per cent of the jobs.

II. THE MACHINE TOOL INDUSTRY IN ALGERIA AND TUNISIA

The table below, which shows the industrial structure of the two countries, indicates the greater proportion of light industries (textiles, clothing, leather and footwear) in Tunisia as compared with Algeria. Algerian industry does not do very much exporting and its exports (around $US 150 million) represent only 1 per cent of the export revenue, while in Tunisia the figure is 61 per cent.

Table 4

Distribution of the value added of the manufacturing industry in 1987

	Algeria		Tunisia	
	$US million	Percentage	$US million	Percentage
Agro-food	2 217	24.0	193	15.7
Textiles, clothing, leather and footwear	1 495	16.2	246	20.0
Wood and paper	580	6.3	79	6.4
Chemicals and petrochemicals	486	5.3	139	11.3
Non-metallic minerals	1 269	13.7	251	20.4
ISMEEI	1 561	16.9	160	13.0
Others	1 625	17.6	162	13.2
	9 233	100.0	1 230	100.0

Table 5

Structure of the ISMEEI

Distribution of value added

	Percentage					US$ million
	381	382	383	384	385	Total
Algeria	34	21	15	29	1	1 561
Tunisia	58	1	23	18	1	160

Source: UNIDO.

Table 6

Industrial exports in millions of US dollars

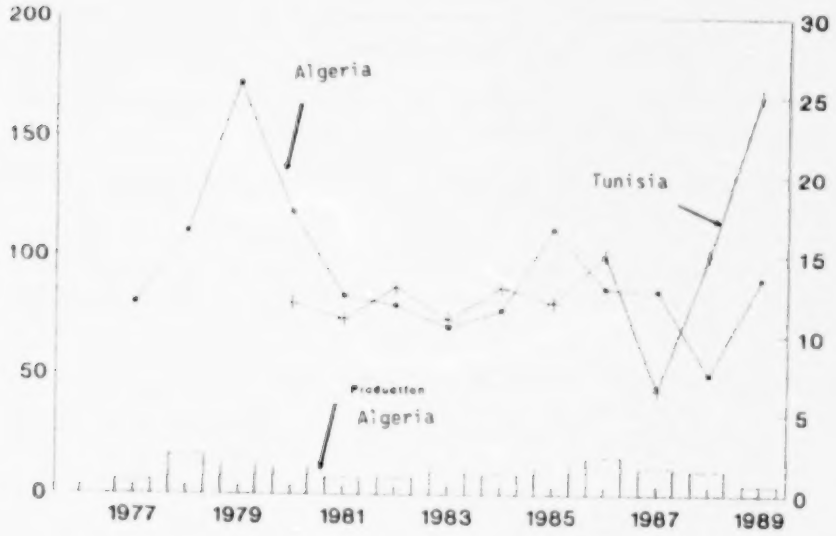
	1981	1988
Algeria	221	154
Tunisia	814	1 617

It can be seen that the ISMEEI play a more important part in the Algerian industry and that their structure is different from that of Tunisia: the metalworking sector represents 58 per cent of the value added of the ISMEEI in Tunisia and 34 per cent in Algeria where, conversely, machine building plays a more important part.

The Algerian machine tool market is on average seven times bigge: than the Tunisian market, a relationship which is similar to the respective share of the ISMEEI in the two countries ($US 1,560 million and 160 million, respectively). As can be seen in figure 1 below, the market fluctuates highly. Trends in the demand in Algeria illustrate the slowing down of investment. Algeria has been making machine tools for 10 years; local production provides only 12 per cent on average of the consumption. Tunisia has recently undertaken a common project with Morocco for the manufacture of woodworking machine tools.

Figure 1

Trends in the demand and production of machine tools in Algeria (left-hand scale) and Tunisia (right-hand scale)



1. Algerian production of machine tools

1.1 History and location

In Algeria the machine tool industry is identified with the activity of the National Machine Tool Production Enterprise (PMO).

Historial background. The enterprise was set up in 1973. At that time it was part of the SONACOME company - the giant of the engineering industry - and remained so until 1983, which was the year when machine tool activity became autonomous following the restructuring of SONACOME.

For its creation contracts were concluded in 1973 with the West German partner DIAG. The work involved, including training and launching of the products, lasted four years - 1974 to 1977. The cost of the plant came to 2,403 million Algerian dinars (at that time one dinar was equivalent to 0.6 DM). Production was started up in May 1977, with the manufacture of the first machine tool in Algeria.

Initial management of the plant, i.e. the technical responsibility, was provided by the technical partner from 1977 to 1979. In that year Algeria became the definitive owner of the plant, with the departure of the West German partner, the plant having attained the requisite economic speed.

The plant is located at Ouad Hamimine (Khroubs), 15 km from Constantine in the north-east part of Algeria.

The enterprise was intended:

- To produce machine tools;
- To develop the machine tool industry and its branches, namely:
  - machine tools for cutting iron
  - machine tools for forming steel
  - machines for injecting plastic materials, together with their accessories and components;
- To identify, study and put into effect all projects pertaining to its specific realm of activity.

At the present time the only unit in operation is the milling machine unit (UTF), which makes conventional cutting machinery, the range of which is as follows:

Production range: conventional machines:

- milling machines: all-purpose 1.5 and 2.5
  horizontal 1.5 and 2.5
  vertical 1.5 and 2.5
- centre lathes: EP 1000 - 1,500 mm-2,000 mm
- drilling machines: pillar type PC 23
  with bench PE 13-16-23
- floor-stand grinders: with base TD 200-300
  without base TD 200-300
- tool grinders: all-purpose type AU.2
- shapers: EL 450
- sawing machines: with bow MA3

Production capacity. The milling unit (UTF) is designed for an annual capacity of 1,200 machines, of which 160 are lathes and 135 milling machines, using two teams of operators. The means of production currently attain optimal utilization: the hourly utilization factor of the installations was 85 per cent in 1989, as against 62 per cent in 1987.

The branches: in conformity with its purpose, the PMO company has a share in the newly created companies:

SOMATOLE: Maghrebian company, for the manufacture of sheet metalworking machines: hydraulic press brakes, hydraulic guillotine shears, hydraulic rollers and blanking and cutting presses (combined).

This new plant is located in the town of BATNA, 100 km to the south of Constantine in Algeria. The construction of it is still under way and it is a joint Tunisian-Algerian project designed for the markets of both countries.

SOMIPLAST: Maghrebian company for manufacturing plastic injection machinery. It is also a joint Tunisian-Algerian project, set up at SETIF in Algeria and intended for the markets of both countries. It is still being built.

MTM: Maghrebian textile machinery for making weaving looms, situated in Tunisia and intended for the markets of both countries. It is still being built.

1.2 Future projects

POC: project for tool manufacture established in the town of Ouenza in the south east of Algeria (Tebessa); production is due to start up in 1990.

Production capacity is 343,500 tools per year.

POA: project for cutting and drawing dies and plastic injection moulds, established at Akbou in Bejaia. It is still being built. Its capacity is 415 sets of tools and 552 moulds per year.

All these projects have been promoted as part of the restructuring, and perspectives for development, of the machine tool industry in Algeria; these topics are gone into further on.

2. Local production

As pointed out further back, the Algerian machine tool industry produces only metal-cutting machine tools of the conventional type. Neither numerically controlled machines, nor metal-forming machines are manufactured in Algeria at the present time.

Table 7

Overall development of the production of metal cutting machine tools in Algeria

YEAR	UNIT	VALUE (millions of Algerian dinars)
1977	184	25.8
1978	534	57.0
1979	579	47.8
1980	484	48.4
1981	350	31.8
1982	648	36.0
1983	709	48.8
1984	834	44.2
1985	828	56.4
1986	1 411	72.2
1987	1 125	55.6
1988	806	62.6
1989	493	27.9
1990*	685	122.0

* Forecast

Table 8

Development of production per group of machinery
Quantity in units and values in millions of Algerian dinars

Designation	1977		1978		1979		1980		1981		1982		1983		1984		1985		1986		1987		1988		1989		1990(*)	
	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V
Lathe	54	8968	55	20398	51	15848	21	9176	21	1636	107	8466	140	11133	143	10353	154	13195	161	12892	60	6431	110	6385	150	11698	140	
Miller	80	15106	99	22919	60	15201	100	21844	101	21182	79	14572	107	22535	89	19681	97	21988	162	30403	119	23844	92	38481	44	10622	170	
Driller	0	0	280	9151	288	9744	115	4236	66	8156	94	4062	235	8275	211	6947	209	7481	352	11964	347	11747	261	10477	33	1389	240	
Floor stand grinder	50	517	70	719	110	1131	100	1028	70	719	237	981	174	1786	315	2655	240	2460	582	5982	491	5044	228	2364	235	2421		
Sawmill	0	0	10	562	40	2247	93	5228	90	5056	131	7978	29	1629	43	1966	76	4270	122	6854	90	5056	115	4888	31	1742	130	
Tool grinder	0	0	20	3244	0	0	5	811	2	324	0	0	12	1947	8	649	20	3244	5	811	15	2433	0	0	0	0		
Shaper	10	1204	0	0	30	3612	50	6019	0	0	0	0	12	1445	25	1926	32	3852	27	3250	3	1083	0	0	0	0		
Total quantity	184		534		579		484		350		648		709		834		828		1411		1125		806		493		685	
Total value rounded off		258		57		478		484		318		360		488		442		564		722		556		626		279		1220

Source: P.M.O.
Q: Quantity in units
V: Value in millions of Algerian dinars
(*): Forecast

Production rose from 184 machines in 1977 (year of start-up) to 1,411 machines in 1986, but then dropped to 493 machines in 1989 because of social conflicts (strikes, etc.). However, the forecasts show a rise (685 machines by 1990).

As can be seen, the number of units produced evolves much more irregularly than does their value. This is due to the production of small size machines such as floor stand grinders. For example, in 1986 production of them amounted to 582 units, or 41.2 per cent of the total production, for a value representing only 8.3 per cent of their total value.

As far as the development of new products is concerned, the PMO enterprise has constructed a milling machine with a digital display system at the level of three axes with the help of a Yugoslav partner first, and then a German partner: Haiden-Haim (FRG). Development of a numerically controlled milling machine is at the design stage and will be carried out together with the same German partner.

Despite the diversity of the range, production is fairly well concentrated on lathes, milling machines and drilling machines. As part of the new PMO strategy, the output of such machines as tool grinders and shapers has already been abandoned. Production will be geared mainly to machines with high value added, such as lathes, milling machines and pillar drilling machines. This explains the high rise in the turnover in 1990, as compared with 1989 and 1988. Accessories as well as machine parts are also being manufactured: milling machine heads and tool grinder accessories. Production of spare parts for machine tools will be conducted on a broader basis.

3. Technological level

Trends in the integration factor: for milling machines the figure is 78 per cent and it is in practice difficult to go beyond that point through lack of national subcontracting capacities. The same problem arises in the case of sawmills and drilling machines, the integration factor for which is 68 per cent. In the case of lathes, the figure is 76 per cent. The integration factor for these products is substantially the same as was noted in 1985.

Products	Integration factor (%)
Milling machines	78
Lathes	76
Drilling machines	65
Sawmills	68
Floor stand grinders	30
Tool grinders	76
Shapers	73

The technical operations carried out and integrated into the plant are:

- Grinding
- Threading
- Broaching
- Gear cutting

- Milling
- Heat treatment
- Painting
- Machine welding
- Numerically controlled programming

Subcontracting: With regard to supply of crude castings, the plant has resorted to imports from its German partner, Fritz Werner (FRG), since the deliveries made by the national complex Mitoyen are insufficient.

Other parts, such as cabling and electric motors, have been delivered by local manufacturers, but national subcontracting is still poor.

Manufacturing licence: For purposes of manufacturing the PMO company has made use of the licences of its German partner Fritz Werner and another, Czechoslovak partner, Tos, especially in the case of lathes. The plant has been operating since 1980 without foreign technical aid.

Prices: Two rises occurred in 1985 and 1989. Prices have to be confirmed by the Ministry of Trade when they have been put forward by the company. Customs duty on imported machine tools is 3 per cent for public enterprises, but the import is subject to quotas; the latter take into account the existence of local manufacture.

The table overleaf shows the prices of a range of products in 1985 and 1989.

Monopoly of distribution and maintenance: In 1983 the national enterprise for distribution of industrial equipment (DEI) resumed its practice of a monopoly on the import of industrial equipment not manufactured in Algeria. In this way DEI ensures the distribution and maintenance of such products. The yearly demand is considered to be relatively stable. Maintenance requirements are greater in the case of metal-cutting machine tools than wood-cutting machinery.

DEI makes purchases by calling for tenders covering the needs of numerous enterprises. It provides an after-sales service for the majority of the equipment purchased and acts with the participation of the supplier in the case of sophisticated products. As far as it can, it also concerns itself with the commissioning of machines for its clients, if necessary with technicians trained by the seller.

However, the PMO company also distributes some of its orders directly to clients.

4. Demand for and stock of machine tools in Tunisia

Since Tunisia does not make machine tools for metal,* analysis of the Tunisian situation will only concern the demand for and stock of machine tools.

4.1 Trend in demand

Since there is no national production, the demand for machine tools is met by means of imports.

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* Tunisia is operating with Morocco in a joint venture for the manufacture of wood-cutting machines (see annex 1).

Table 9

Difference in selling price 1985 and 1989 (in Algerian dinars)
(margin of 23 per cent)

Product	Manufacturer's supply price 1985 (1)	Price proposed 1989 (2)	Difference (2)-(1)	%
Lathe Dos 1000	75 828	115 500	+39 672	52
Lathe Dos 1500	78 597	117 800	+39 213	50
Lathe Dos 2000	81 054	120 100	+39 046	48
Lathe Junior 1000	325 891	325 900	+9	0
Lathe Junior 1500	-	345 000	-	-
Lathe Junior 2000	-	350 000	-	-
Milling machine HF 1.5 + Head UF 1.5	221 222	249 400	+28 178	13
Milling machine HF 1.5 + Head VF 1.5	204 814	275 100	+70 286	34
Milling machine UF 1.5 + Head UF 1.5	236 173	324 000	+87 827	37
Milling machine HF 1.6 + Head	227 074	268 100	+41 026	18
Milling machine HF 1.5 + Head VF 1.5	-	237 000	-	-
Milling machine VF 2.5 + Head	263 268	400 400	+137 132	52
Milling machine HF 2.5 + Head VF 2.5	317 507	423 800	+106 293	33
Milling machine UF 2.5 + Head	319 502	406 500	+86 998	27
Drilling machine PE 13	23 536	27 600	+4 064	17
Drilling machine PE 16	30 624	46 600	+15 976	52
Drilling machine PE 23	32 631	49 400	+16 768	51
Drilling machine PC 23	43 217	55 800	+12 583	29
Drilling machine PC 30	44 206	61 000	+16 794	38
Floor stand grinder TD 200	10 214	10 214	0	0
Floor stand grinder TD 300	10 331	10 331	0	0
Sawmill SMA 3	56 180	70 600	+14 420	26
Shaper EL 450	120 386	166 000	+45 614	38
Tool grinder AU 2	162 224	143 300	-18 924	(12)
VF 1.6 + Head VF 1.5	-	230 600	-	-

Source: PMD.

Importation relates more to metal-cutting machines than to metal-forming machines (see table overleaf). The proportion of the first category varies between 59 and 83 per cent, or an average of 69 per cent over the period 1980 to 1989, while the share of the second category varies from 17 to 41 per cent, or an average of 31 per cent over the same period.

It should be pointed out that a project for the manufacture of small numerically-controlled machining centres intended for export is currently being studied in Tunisia with Italian partners as part of the joint Tunisian-Algerian project SAKMO which is already operational.

This project bears the features of one that uses up a great deal of capital but does not create many jobs (and it will exhaust the Italian credit line for financing projects co-promoted with Italian partners).

Table 10

Development in the import of machine tools (1980-1989)
(Value in millions of Tunisian dinars)

	Total imports		Metal-cutting machines		Metal-forming machines	
		Mean annual growth rate		%		%
1980	5.8		3.7	64	2.1	36
1981	6.5	12	4.4	68	2.1	32
1982	8.6	32	5.6	65	3.0	35
1983	8.7	1	5.6	64	3.1	36
1984	10.6	22	6.6	62	4.0	38
1985	9.4	-11	5.5	59	3.9	41
1986	12.3	31	8.5	69	3.8	31
1987	5.7	-54	4.1	72	1.6	28
1988	14.1	147	11.6	82	2.5	18
1989	23.7	68	19.7	83	4	17

Imports showed a regular progression from 1980 to 1986. A fall which did not last long was recorded in 1987 and since 1988 there has been a strong uptrend.

The mean annual growth rate for 1980 to 1989 is about 23.

Table 11

The principal supplier countries are as follows
(percentage in terms of value)

	1980	1984	1986	1989
France	38	23	33	17
Italy	33	22	30	56
FRG	10	10	9	4
Spain	4	10	6	10
Eastern Europe (USSR, Yugoslavia, Bulgaria, Poland, GDR)	4	23	4	5

It transpires that France and Italy take first place with more than 65 per cent of imports; the Federal Republic of Germany and Spain come next.

Among the metal-cutting machines, the main imports in terms of value are:

Table 12

Main products
(percentage in terms of value)

	1980	1982	1984	1986	1988	1989
Lathes	19	25	20	15	24	16
Milling machines	5	8	10	9	8	15
Tool grinders + Grinders	15	14	15	12	13	21
Drilling machines	6	4	5	1	8	6
Sawmills	9	5	6	6	1	3

Lathes occupy first place, then come tool grinders and grinders and finally the milling machines, drilling machines and sawmills.

Table 13

Import of numerically controlled machine tools: share of numerically controlled machine tools in total imports
(value in millions of Tunisian dinars)

	Total imports	Share of NCMT	
		Value	%
1980	5.8	0.19	3
1981	6.5	0.21	3
1982	8.6	0.29	3
1983	8.7	0.17	2
1984	10.6	0.12	1
1985	9.4	0.15	2
1986	12.3	1.22	10
1987	5.7	0.53	9
1988	14.1	1.9	13
1989	23.7	0.81	3

Numerically controlled machine tool imports averaged 2.5 per cent of the machine tool imports between 1980 and 1985, and 7 per cent between 1988 and 1989.

This relates mainly to the import of machining centres, lathes and milling machines. The countries from where the imports originate are Japan, Italy and the Federal Republic of Germany.

4.2. Machine tool park in Tunisia

4.2.1. Conventional machine tool park

The machine tool park is estimated by counting the number and types of machines on the basis of lists of enterprises appearing in the technical yearbook on subcontracting for 1988, prepared by CETIME (Technical Centre for Mechanical and Electrical Design), the yearbook of the electrical and electronics industries (1986-1987) and the yearbook of the automobile component industry sector in Tunisia (1985-1986), both of these prepared by API (Industrial Promotion Agency).

In the case of metal cutting machine tools and excepting the machines belonging to industrial-size enterprises, account has been taken of the machines installed in the repair shops at artisan level. As a whole a workshop of this type usually has a lathe, a milling machine and a drilling machine (all of them conventional). It is estimated that the proportion of the machines in that category of user represents 10 per cent of the park of machine tools used for cutting metal.

On this basis the conventional machine tool park is calculated at about 2,270 units of all categories taken together and distributed as follows (see the table below):

- 1,500 metal cutting machine tools, of which 1,360 are used in enterprises of the industrial type;
- 736 metal forming machine tools.

The metal cutting machine tools represent about two-thirds (67 per cent) of the total park and are mainly used in the metallurgical, engineering, electrical and electronic industries.

The machines used the most are lathes (38 per cent), milling machines (17 per cent), drilling machines (22 per cent) and grinding machines (8 per cent).

Table 14

Conventional metal cutting machine tool park in Tunisia (recapitulatory)

Machines	%	Number (Unit)
Lathes	37.2	508 of which 84% are centre lathes
Milling machines	16.6	226 of which 64% are all-purpose milling machines
Drilling machines	22.3	304 of which 27% are radial drilling machines 19% are pillar-type drilling machines 10% are tapping drilling machines
Grinding machines	8.3	113 of which 52% are cylindrical 42% plane 6% centreless
Tool grinders and floor stand grinders	2.8	38 of which 27% are tool grinders
Sawmills	4.5	61 of which 51% are sawing machines
Boring machines	3.2	43
Shapers	2.2	30
Planing machines	0.7	9
Mortising machines	0.7	8
Gear-cutting machines	0.4	6 of which 5 are straight cylindrical and helical 1 is straight cylindrical
Transfer machining appliances	0.7	8
Electro-spark erosion appliances	0.4	5 which are of two different types
	100	1,359

Sources: Technical Yearbook of Subcontracting (1988) - CETIME.

Yearbook of the Electrical and Electronics Industries (1986-1987) - API.

Yearbook of the automobile component sector in Tunisia (1985-1986) - API.

Table 15

Detailed conventional machine tool park for metal cutting in Tunisia

Machines	Types	Units
Turning	Centre lathes	425
	Vertical lathes	8
	Turret lathes	12
	Sliding lathes	6
	Automatic lathes	22
	Facing lathes	6
	Front operated lathes	1
	Second-operation lathes	3
	Semi-automatic lathes	4
	Automatic lathes	13
	Cutting lathes	2
	Multiple spindle lathes	2
	Other types	4
		508
Milling	All-purpose milling machines	145
	Vertical milling machines	16
	Console milling machines	10
	Horizontal milling machines	5
	Automatic milling machines	7
	Copying milling machines	1
	Surface milling machines	1
	Boring-milling machines	6
	Groove milling machines	2
	Others	33
		226
Boring	Boring machines	43
Grinding	Plane grinders (travel from 300 to 1,600)	49
	Cylindrical grinders, of which:	57
	- internal 1	
	- external 10	
	- internal + external 15	
	- others 31	
	Centreless grinding machines	7
		113

Machines	Types	Units
Drilling	Radial drilling machines	83
	Pillar drilling machines	57
	Tapping-drilling machines	23
	Drilling machines Ø 50	20
	Others (including tapping machines)	118
		304
Broaching and planing	Shapers	30
	Surface milling machines	9
	Mortising machines	8
		47
Gear-cutting	Cylindrical cutting machines (straight piece maximum Ø 500)	1
	Cylindrical cutting machines (straight and helical)	5
		6
Electro-spark erosion machines	Type "à fils"	3
	Type "à enfoncer"	2
		5
Transfer machining	Rotary	4
	Automatic	2
	Six headed	1
	Special borer	1
		8
Sawmills	Sawing machines	31
	Alternating saws	11
	Circular saws	12
	Disk saws	7
		61

Machines	Types	Units
	Tool grinders	27
	Floor stand grinders	11
		38
Total for metal cutting machine tools		1 359

Table 16

Conventional metal forming machine tool park in Tunisia (recapitulatory)

Machines	%	Number (Unit)
Blanking and drawing press	28	209, of which 51% are mechanical presses
Press brakes	19	140, of which 44% are mechanical benders
Shears	27	200
Bending machines	10	75
Punching machines	7	48
Forges	6	46
Nibblers	2	18
	100	736

Sources: Technical Yearbook for Subcontracting (1988) - CETIME.

Yearbook of the Electrical and Electronics Industries (1986-1987) - API.

Yearbook for the automobile component industry in Tunisia (1985-1986) - API.

Table 17

Detailed park of conventional metal forming machine tools in Tunisia

Machines	Types	Units
Blanking and drawing	Mechanical presses	107
	Hydraulic presses	92
	Other presses	73
		209
Bending	Profile benders	11
	Roller benders	25
	Tube benders and others	39
		75
Shearing	Guillotine shears	150
	All-purpose shears	25
	Other shears	25
		200
Nibbling	Nibblers	18
Punching	Punching machines	25
	Punching-shearing machines	9
	Punching-nibbling machines	3
	Other punching machines	11
		48
Forging	Hot presses	15
	Cold presses	21
	Drop hammers	10
		46
Bending	Mechanical bending presses	61
	Hydraulic bending presses	41
	Other presses	38
Total number of metal forming machine tools		736

Regarding the metal forming machine tools, the most commonly used are blanking and drawing presses (20 per cent), shears (27 per cent), press brakes (19 per cent), and other benders (10 per cent).

The state of the machine park is marked to a large extent by the delapidation and obsolescence of the equipment. Approximately half the machines should be replaced.

4.2.2 Numerically controlled machine tool park

The park of numerically controlled machine tools in Tunisia is calculated at about 60 machines of all categories taken together, distributed over 20 enterprises. The metal cutting machine tools represent about 82 per cent of the park in terms of the number of units. The bulk of them belong to the company SAKMO and are used for the manufacture of low-range diesel motors under a joint Tunisian-Algerian project (14 machining centres). (See table below.) The main supplier is Italy.

The numerically controlled machine tool park represents only about 2.6 per cent of the total park of machine tools, which is calculated at 2,290 units.

Table 18

Numerically controlled machine tool park in Tunisia

Metal-cutting machine tools

Companies	Machining centres	Milling machines	Lathes	Grinders
	(a) Industries			
SAKMO	14	1	2	1
ATLAS MOTEURS	1		1	
ATLAS POMPES			1	
C.M.T.		3	4	
F.T.E.		1	1	
HYDROMECA			1	
HYDROMECANIQUE			1	
M.M.B.			1	
A.M.I.	1			
PRECIMECA	1		1	
TECHNMO			1	
CETIME		3		
L.T.O.		2		
REBAI ET INDUSTRIE	1			

Companies	Machining centres	Milling machines	Lathes	Grinders
(b) Engineering schools and training centres				
ENIM	1		1	
ENIT		1		
C.N.M.G.		2		
TOTAL	20	13	15	1
GRAND TOTAL: 49				

Numerically controlled machine tool park in Tunisia
Metal forming machine tools

	Shearing-punching machines	Punching machines	Nibblers	Press brakes	Grinders
C.M.T.				1	
S.G.I.	2	2			
C.T.M.			1	1	
M.M.B.				1	
BESBES INDUSTRIE					1
A.C.E.M.				1	
TOTAL	2	2	1	4	1
GRAND TOTAL: 10					

Sources: Surveys; Technical Yearbook of Subcontracting (1988) - CETIME.

In the case of the SAKMO enterprise, the numerically controlled machine tools will exceed about 30. In order to master the techniques and maintain this production tool in the best conditions, SAKMO, while looking for standardization of the numerically controlled park, has planned to set up a training centre specializing in instruction in maintenance, programming and

design of automated numerically controlled machine tools as well as other equipment such as the programmable automated devices and variable speed drives. The centre, which will be set up together with the French company NUM, will have models of very modern teaching equipment and numerically controlled machine tools (six training posts).

The introduction of numerically controlled machine tools as a means of production is tending to spread to projects for the manufacture of capital goods or mechanical parts, especially to new projects. The example of SAKMO described above is an indication of this, while MMB (Maghrebian wood-cutting machines) is another example. Initially, the project envisaged only conventional machine tools as the means of manufacture; restructuring of the project resulted in replacement of the 15 conventional machines by four numerically controlled machines (CNC) involving an additional investment of 30 per cent; recovery of the excess costs is largely compensated by a reduction in the cost of manpower. Whereas it was planned to employ 20 persons for the conventional option, the introduction of the machine tools has reduced the staff to six.

4.2.3 Distribution of machine tools

In Tunisia machine tools are imported first by five commercial companies, namely: Mine-Usine et Comptoirs Réunis, Revolon, Tunimatec, Soto and Rondon, and second, by the industries themselves as part of the creation of new manufacturing projects. The investment code in Tunisia authorizes promoters to import their production equipment directly.

The enterprise Mine-Usine is the only one semi-State-owned, the others are companies in the hands of private promoters. Only two companies provide their clientele with after-sales service, namely Mine-Usine and Soto. As a whole, the purchasers repair their own machines in the event of breakdown.

The taxes to be paid on machine tool imports are:

- Customs duty - 10 per cent
- VAT - 17 per cent.

5. Predicted demand for machine tools in Algeria and Tunisia

A number of studies have made it possible to evaluate the trends in the demand for machine tools in Algeria and Tunisia as well as in the Arab countries as a whole.

5.1 Market trends

According to the results of a study made for the Arab Industrial Development Organization (AIDO), the Arab machine tool market should increase by 5.4 per cent per year during the 1990s and attain $US 882 million by the year 2000 (in constant 1980 dollars).

Three statistical methods have been used to estimate the trend in demand:

Method 1:

Analysis of linear trends in previous consumption on the basis of the following equation (in the case of Tunisia):

$$DT = 3.324 + 0.4358\ t,$$

where DT is the demand over the period "t"

t is a time variable (reference year 1974)

and the correlation coefficient r = 0.9095.

Method 2:

The demand is calculated using the following equation:

$$DT = 3.4303\ t\ 0.3086$$

where DT = the demand over the period "t"

t is a time variable (base year 1974)

and the correlation coefficient r = 0.9264.

Method 3:

The demand is calculated on the basis of the ratio between the GFCF (gross fixed capital formation) and the machine tool consumption.

The following equation takes account of the linear regression noted between these two variables:

$$DT = 0.14598 + 6.1139 \times 10^{-3}\ {}_{G}T_{t}$$

where DT is the demand over the period "t"

t = a period of time (reference year 1974)

and the correlation coefficient r = 0.9279.

In the case of Tunisia the three methods predict the following growth rates for the years 1990-2000:

Method 1: 4.8

Method 2: 2.3

Method 3: 5.5 (the growth of the GFCF has been estimated at 5.5 per cent).

The results of method 2 have been selected in our study.

Table 19

Predicted demand in machine tools for metalworking in the Arab region (in terms of value at constant 1980 prices)

(A) Countries which have carried out a field survey

Country	Value (in millions of $US) Previous 1980	Predicted 1990	2000	Mean annual growth 1980-1990	1980-2000	Share of the market (%) 1980	1990	2000
(A)								
Algeria	123.48	202.17	316.92	4.6	4.6	41.8	29.5	35.9
Egypt	21.73	44.94	82.27	7.5	6.9	7.1	8.8	9.3
Iraq	32.54	41.53	74.38	2.5	4.2	10.6	8.1	8.4
Jordan	4.07	8.30	14.87	7.4	6.7	1.3	1.6	1.7
Libya	5.13	7.73	17.30	4.2	6.3	1.7	1.5	2.0
Morocco	12.67	22.85	37.96	6.1	5.6	4.1	4.5	4.3
Saudi Arabia	45.51	86.71	172.12	6.7	6.9	14.8	17.0	19.5
Syria	11.18	20.09	36.34	6.0	6.1	3.7	3.9	4.1
Tunisia	15.12	26.19	42.43	5.6	5.3	4.9	5.1	4.8
Subtotal	276.43	460.51	794.59	5.2	5.4	90.0	90.0	90.0
(B) Other Arab countries	30.78	51.17	88.29	5.2	5.4	10.0	10.0	10.0
GRAND TOTAL (rounded off)	307.21 (307)	511.68 (510)	882.88 (880)	5.2	5.4	100.0	100.0	100.0

Source: AIDO survey: "Study on the development of machine tools in the Arab world" (1987).

Algeria will remain the principal machine tool market among the Arab countries. The share of the Algerian market, which was 40.5 per cent of the market of the Arab countries in 1980, should fall off slightly, attaining 35.9 per cent by the year 2000. Tunisia's share should remain constant (5 per cent approximately).

5.2 Predicted demand for numerically controlled machine tools

The share of the numerically controlled machine tools (NCMT) has been calculated at 1 per cent of the value of the machine tools in 1980, and 4 per cent in 1990 for the Arab countries as a whole (5 per cent in the case of Tunisia). This proportion should progressively increase and reach 7.5 per cent by the year 2000.

The demand for numerically controlled machine tools will develop at an average rate of 10 per cent during the period 1990-2000. In the case of Algeria it has been calculated that yearly imports of numerically controlled machine tools will amount to 300 units by the year 2000.

III. CONCLUSIONS

1. The experience of developing countries in the manufacture of machine tools

The need for the developing countries to establish an industry for assembling machine tools as an integral part of their capital goods industry calls for industrial and economic development and the ability to "rely on oneself" in the technical field.

The development of the machine tool assembly industries in the developing countries normally follows the natural procedure shown below:

First stage: Initially, standard machine tools are imported from the developed countries and their economic efficiency increases with the experience acquired in loading, utilizing and maintaining the machines, the tools and the accessories.

Second stage: This stage is linked to the intelligent copying of standard and simpler equipment. Capabilities available at local level with regard to the design and manufacture of parts are put to use (for certain types of products).

Third stage: The ability to copy and manufacture simple machines and equipment already existent creates the need to make more complex and higher-quality machinery.

Under these conditions and to avoid resorting to costly experiments with existing machines, foreign collaboration is permitted and in the short run produces better results.

Fourth stage: The final stage of designing and manufacturing complex and productive machines is reached after the technology has been assimilated. At this stage capabilities linked to the adaptation and modification of engineering designs as well as organizational and managerial capacities will have been adequately developed.

The experience gained by the developing countries is manifold and extensive. In accordance with its specific characteristics each country has adopted its own line of approach in order to reach the present stage in the field of machine tools (China, South Korea, India, Taiwan, etc.).

A viable and productive machine tool industry in the developing countries needs adequate support from their respective Governments (customs protection, support for prices, etc.). The essential preconditions for the development of the machine tool industry are:

- The size of the market;
- The basic infrastructure;
- Technical, design, engineering and managerial competence;
- Protection of the market by the creation of customs barriers over a fairly long period.

Furthermore, certain conditions have to be met in the area of infrastructure:

- Establishment of well-equipped foundries meeting the requirements of machine tools;
- An iron and steel industry making it possible to manufacture high-quality alloys;
- Plants manufacturing cutting tools (carbide, etc.);
- Institutions offering advanced training in the design, production engineering, industrial engineering, plant management, etc.;
- A research and development centre;
- Other units providing support for machine tools (bearings, AC or DC induction motor, etc.).

2. Integration or decentralization of production: the case of Algeria

2.1 The choice of the decentralization level

The Algerian machine tool industry has been designed on the basis of a model permitting integration. As part of the industrial restructuring under way and to satisfy future local demand, several variants and scenarios have been looked at:

(1) Variant No. 1

This alternative advocates production of all the machines in the same manufacturing unit. The nucleus is the present milling machine unit (UTF), the surface area of which will be extended.

The advantages of this version are:

- The machines are used properly;
- There is efficient communication and cooperation between the different workshops;

- There is higher labour productivity;

- Experience acquired is put to better use.

The major disadvantage of this alternative is an unduly high concentration of staff and that was the reason why it was discarded.

(2) Variant No. 2

This advocates the establishment of five medium-size manufacturing units. The size of each unit should not exceed 600 employees (with the exception of the present UIF unit).

In this variant consideration has been given to two projects under way. These are:

- A project for the manufacture of MEDA mechanical presses;

- A joint Tunisian-Algerian project for the manufacture of machinery for working the sheet metal made by SOMATO.

The advantage of this option would be the possibility of diversifying the units at national level.

(3) Variant No. 3

This is based on the creation of nine small size production units. The present milling machine unit would specialize in the manufacture of mechanical presses and sheet metalworking machines.

Just as for variant 2, variant 3 takes into account projects under way for mechanical presses and sheet metalworking machines. The number of employees in each unit varies from 50 to about 580 persons. Some units could be given over to the private sector under the supervision of the PMO company, which would carry out quality control.

For the time being it is the third variant which has been selected.

It also takes into account the family of simpler and less important machines, especially tools and equipment for manual labour.

The distribution of the machine tools to be produced as well as the planned production by each unit are summarized below.

2.2 Production programme

The programme is aimed at producing a range of machines which by virtue of the degree of complexity of their mechanical components will create the conditions required for the development of numerically controlled machines and for an increase in the proportion of them.

The conditions specific to Algeria are as follows:

- Machine tool production is only in its infancy;

- The country has a reserve of manpower to be trained and used in the proper way;

- The private sector is beginning to develop and there is good reason to provide it with a basic nucleus of machine tools: some units can be handed over to private promoters;

- Algeria is in a position to export its products;

- The management and staff of the PMO have enough sound experience to launch the manufacture of numerically controlled machine tools, as witnessed by the degree of full autonomy in the management of PMO (technical and financial) and the work of developing new machine tools.

2.3 Operational planning

In the short term: the present milling machine unit (UTF) will tend to specialize in the manufacture of lathes and milling machines. The manufacture of the other smaller and simpler machine tools will be transferred to new units to be set up for the production of floor stand grinders, alternating saws and drilling machines.

The next stage will involve setting up a new unit for making milling machines and reserving the present UTF for turning out lathes. During the third stage other units will be constructed and will concern themselves with machines of both families; some of these units could be handed over to private persons.

2.4 Technological difficulties

The construction of these units presupposes that the problems of purchasing technologies and finding partners with manufacturing licences will be solved, since from the outset these technologies are adapted to suit the sponsor's machine park.

A certain standardization (adaptation) of the technology is therefore necessary, above all in the following areas:

- Use of manufacturing materials (local and imported materials);

- Heat treatment;

- Modifications adapted to the manufacture of components.

This standardization should be done above all at the level of technology, mounting (use of items and devices with standard mountings) and use of standard tools and appliances (above all the special type).

These technological norms are necessary first and foremost for the economical use of numerically controlled and computer numerically controlled machines when manufactured in small batches.

- Subcontracting in Algeria for certain locally made components (electric motors, distribution panels, interrupters, etc.) which have to be adapted to suit the technology selected for the manufacture of the machines with regard for the fact that the number of subcontractors is greatly limited;

- Strengthening of future co-operation with other Algerian enterprises.

Table 20

Variant No. 3: Planned production units

Units	Type of machine to be produced	Production planned (Units/y)
1	Centre lathes	350
	Centre precision lathes	250
	Turret lathes	200
	Numerically controlled lathes	80
		880
2	Radial drilling machines	280
	Horizontal console milling machines	80
	All-purpose console milling machines	120
	Numerically controlled milling machines	40
		520
3	Cylindrical grinding machines	80
	Horizontal plane surfacing machines	100
	Tool grinder	70
		250
4	Alternating saw mills	90
	Circular saw mills	140
	Band sawing machines, Q max: 250 mm	200
	Pillar drilling machines	1 100
	Simple drilling machines, Q 13 mm	200
		1 730
5	Mechanical rollers for sheet metal	57
	Press brakes	57
	Combined shears for shaping	143
	Hydraulic guillotine shears	86
	Sheet metal bending machines	86
		429
6	Tilting eccentric press	400
7	Floor stand grinders (1 or 2 disks)	1 150
	Band-type polishing machines	100
	Abrasive disk cutters	1 400
		2 550
8	Manual bending machine for sheet metal	500
	Manual rollers for sheet metal	450
	Manual combined shears for shaping	1 100
	Bordering machine	1 050
		3 100
9	Manually operated presses	320
	Hydraulic assembly presses	70
	Manual hydraulic tube bender	400
		790

Furthermore, and to ensure success in launching production, it is essential to premanufacture special tools and appliances, and then to devise programmes for NC and CNC machines and manufacturing processes.

Ensuring the rapid development of each unit is dependent on whether the problems mentioned above can be solved. Production will start up with the manufacture of basic components and with the importation of most of the parts; their importation will be expected to decrease as production progresses so that in the long run only a strict minimum will be kept (NC systems, control systems, some electrical appliances, bearings, etc.).

Finally, internal subcontracting between the units that are to be set up should be optimal, above all for special operations such as gear cutting, bar threading, heat treatment, certain machining operations, and so forth.

It should be noted that a plant for making cutting tools is under construction in Algeria, together with another one for the manufacture of cutting and drawing appliances and injection moulding dies with Chinese help, this being already one step completed.

Table 21

Specifications of machine tools to be made in Algeria

Designation	Unit	Minimum	Mean	Maximum	Type of control
Centre lathe	B	400	500	630	
	ØD	220	270	340	M
	L	1 000	1 500	2 500	
Precision centre lathe	B	320	400	630	M
	ØD	180	320	350	N
	L	750	1 000	2 000	D
Turret lathe	Ød	40	50	63	M
	ØD	140	255	270	N
	L	300	250	325	
Semi-automatic lathe	B	320	400	490	
	ØD	160	200	320	N
	L	800	1 000	1 400	
Radial drilling machine	Øb	32	50	63	
	v	1 000	1 250	1 600	M
Milling machine with console	s	300	400	500	M
	l	1 000	1 400	1 400	N
	p	U	HVU	HVU	
Milling machine with console	s	250	320	400	
	l	1 000	1 250	1 600	M
	p	U	HVU	HVU	
Alternating saw	Øm	-	250	-	M
	sxl	-	250 x 270	-	
	h	-	138	-	
Circular saw	Øm	-	140	-	
	K	-	400	-	M
Cylindrical external grinder	D	250	320	400	M
	L	630	1 000	1 500	(D)
	K	600 x 80	600 x 80	600 x 80	
Plane horizontal grinder	s	160	320	400	M
	l	320	1 000	1 500	M(D)
	K	175 x 16	300 x 25	300 x 40	
All-purpose grinder	xsl	-	10 x 850		
	L/H	-	500/115		M
	K	-	175		
Sheet metal rolling machine	t	4	8	10	
	z	2 000	2 000	2 000	M
Press brake	KN	500	1 250	2 000	
	v	2 500	3 150	4 000	M
	h	65	80	100	
Eccentric press	kN	500	1 000	1 600	
	v	260	320	355	M
	h	125	120	120	
Tilting eccentric press	kN	80	350	500	
	v	110	250	280	M
	h	42	100	150	

Table 21 (continued)

Specifications of machine tools to be made in Algeria

Designation	Unit	Minimum	Mean	Maximum	Type of control
Combined section cutting shears	t	–	10	–	M
	z	–	150	–	
	Øm	–	25	–	
Hydraulic guillotine shears	t	6.3	10	16	M
	z	1 200	2 000	3 150	
Manual sheet metal bending machine	kN	7	15	30	R
	h	210	380	740	
	v	150	245	350	
Manual comb press	kN	7	15	30	R
	h	210	380	740	
	v	150	245	350	
Mechanical sheet metal bending machine	t	4	6	10	M
	z	2 000	2 000	2 000	
Pillar drill with bench	Øb	16	23	32	M
	sxl	250 x 280	290 x 320	316 x 400	
	l	80	120	200	
Floor stand grinders	k	200 x 25	200 x 25	300 x 40	M
	n	3 000	2 125/3 500	1 500	
	v	51	–	76	
Grinding and polishing machine	sp	–	500		M
	o		1 000		
Hydraulic mounting press	kN	100 x 40	300 x 150	800/20	M
	h	400	250	185	
	v	215	300	320/750	
Bench drill	Øb	6	10	13	M
Manual sheet metal rolling machine	t	1	2	3	R
	z	1 000	1 000	1 000	
Tube bending press (manual, hydraulic)	kN	–	103	–	R
	bm	–	3/8-3	–	
	R	–	40/355	–	
Band saw	Øm	–	280	–	M
	w	–	17.5-125	–	
Cut-off machine with abrasive wheel	Øm	–	40/80	–	M
	k	–	600	–	
Milling machine with console					
Combined manual section-cutting shears	t	–	10	–	R
	z	–	120	–	
	om	–	25	–	
Sheet metal welding machine	o	–	50-70	–	R
	r	–	280	–	
	t	–	1	–	

Table 21 (continued)

Specifications of machine tools to be made in Algeria

LEGEND:

B: Diameter of pass above bench (mm)
b: Diameter drilled (steel) (mm)
D: Gap diameter (mm)
d: Diameter of pass on the spindle (mm)
H: Maximum working height (mm)
h: Cutting stroke (mm)
L: Distance between points (mm)
l: Mounting length (mm)
m: Mounting diameter (mm)
n: Turns (1/min)
K: Diameter of wheel/saw (mm)
o: Distance between rollers (mm)
P: Arrangement (H: horizontal; V: vertical; U: universal)
R: Diameter of bend (mm)
s: Breadth of mounting (mm)
sp: Breadth of polishing band (mm)
T: Depth pierced (mm)
t: Thickness of machined part (of the material) (mm)
u: Working breadth (mm)
V: Advance of the spindle (mm)
W: Cutting speed
z: Breadth of the machined part (of the material) (mm)
KN: Working power (KN)

CONTROL

M: Manual control of the parts of the hydraulic control system
H: Manual control
N: Numerical control NC/CNC
(D): Digital position finding of the tool

3. Diffusion of numerical control: the case of Tunisia

Despite the queries they give rise to in the developing countries, the new technologies (CAD/CAM and numerical control) have shown their ability to meet the challenges of quality, deadlines and cost. The quality grade now accepted at international level can be obtained only with precision machines, which call for computer and numerical control.

This point, moreoever, was confirmed during the Seminar on numerically controlled machine tools in the developing countries organized by UNIDO in connection with the seventh international machine tool exhibition and held at Milan (October 1987):

- Industrial production and data processing are a real threat to the competitivity of engineering industries in the developing countries. To confront the threat, these industries must equip themselves with up-to-date machines;

- The age of the CNC has arrived! It is no longer possible to be competitive with manual or conventional machines.

The major obstacles barring the way to their diffusion in small and medium enterprises are still a question of financial means and information; that finding induces us to think about the type and nature of the channels for providing aid, information and assistance to small and medium-sized enterprises in Tunisia, while making allowance for the sectoral priorities.

In this connection it is worth bearing in mind the machinery of this kind that was used both in Germany and in France with the Meca procedure to encourage investment in equipment and with the Loic procedure for investment in software.

These procedures have been instituted by the French public authorities and administered by ADEPA (Association for the Development of Automated Production):

- At the level of training and instruction there is need to introduce and to broaden the scope of instruction in numerical control in the lycées, training centres and university institutions as well as in the engineering schools by setting up workstations and workshops for CAD/CAM, etc.;

- These measures should be defined in a development strategy which, while taking into account the endogenous constraints (competence of staff, industrial potential, financial resources, etc.) and exogenous constraints (future market requirements, emergence of new technology, etc.) should make it possible to undertake modernization programmes in time in the areas of manpower (training and instruction of staff), technology (old technology), industry (choice of equipment) and commerce (control of markets);

- This action if properly pursued would be such as to help spread, in the long run, an industrial culture by which to maintain contact with the industrialized countries and to remain permanently open to trade and international co-operation in the industrial field.

The introduction of these new techniques is therefore neither a luxury nor a fashion, nor the prerogative of the developed countries, but a vital need for Tunisian industry. Need one recall the problems that Tunisia is facing? Firstly, the drawing up of resources (energy and raw materials) and, second, the presence on the job market of young people with multiple competences. All that within a context of the internationalization of the economy and rapid advance in know-how and new techniques. It is thus essential, in fact a matter of urgency, to prepare the framework and the favourable conditions for introducing and mastering these new production and management techniques so that the Tunisian industrial fabric can make the changes that all countries recognize, whether industrialized or developing countries (especially in South-East Asia and China).

Annex

Maghrebian Wood-working Machines (MMB)

The case of MMB

In conformity with the role assigned to the engineering sector in the fifth plan, the Tunisian Bank for Economic Development has promoted a unit for manufacturing woodworking machines with the technical assistance of a French partner of world renown.

This plant, which is called Maghreb Wood-working Machines, and which started up production in 1985, is the first of its kind in the Maghreb. It has enabled Tunisia to go beyond the stage of a simple user and become a maker of capital goods.

The project has also been the first joint Tunisian-Moroccan project promoted with the collaboration of the Moroccan Office for Industrial Development.

The objective of this is to make 1,000 machines per year of four different types, 500 of which will be destined for the Moroccan market.

In order to ensure competitivity in terms of costs and quality on an equal footing with foreign competitors, means of production with high technological value (numerically controlled machining centre) have been set up with the appropriate computer-aided control.

MMB manufactures capital goods and has been able to attain integration factors higher than 50 per cent over the range produced in collaboration with foreign partners (figures similar to those of the partners themselves). It has been able to develop its own products and by investing in the development of the enterprise itself and - indirectly - by mobilizing some of the national subcontractors (especially foundries).

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CONDITIONS OF ENTRY AND MEASURES TO PROMOTE COMPETITIVE LOCAL PRODUCTION AND EFFECTIVE UTILIZATION OF MACHINE TOOLS

Issue paper*

Prepared by

the UNIDO Secretariat

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Summary

Entry into the machine-tool industry and identification of measures to promote competitive local production require a clear understanding of the operations of the industry on a world-wide basis. A comparative analysis of the world-wide operations of the industry vis-a-vis that in the developing countries would then facilitate determination of the constraints and opportunities confronted by the latter countries in entering and sustaining their machine-tool industries.

While not all developing countries may wish to engage in production of machine tools, their effective utilization is important for all countries. Of major concern for developing countries are the implications of increasing utilization of numerical control machine tools and other flexible automation equipment in the engineering industries of the industrialized countries. It is important to consider the social impact of these new technologies and the appropriateness of associated organizational innovations in the context of the industrial environment in developing countries.

Greater participation of the private sector in engineering industries requires examination of financing problems and industrial and entrepreneurial policies. New approaches are required to address the financing problems of the sector which could include debt-conversion schemes, as well as leasing arrangements. The specific problems of small and medium scale enterprises merit special attention due to their pre-eminent role in the sector.

Certain industrial processes in engineering industries could have detrimental environmental impacts if adequate precautions are not taken. Enhanced international co-operation, in terms of provision of technical expertise in environmental management, and increased promotion of cleaner production technologies, would alleviate these problems. International organisations and transnational corporations can play a major role in this respect.

Explanatory Notes

References to dollars ($) are to United States dollars, unless otherwise indicated.

The following abbreviations are used in this report:

CIM	Computer Integrated Manufacturing
CNC	Computer Numerical Control
FMC	Flexible Manufacturing Cell
FMS	Flexible Manufacturing System
FRG	Federal Republic of Germany
GDR	German Democratic Republic
ISIC	International Standard Industrial Classification
NC	Numerical Control
R&D	Research and Development
U.S.A.	United States of America
USSR	Union of Soviet Socialist Republics

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INTRODUCTION

1. Previous Consultations on the Capital Goods Industry have emphasized the central role of this sector in the industrialization process, and drew attention to the consequences of the gross imbalances in the state of its development between industrialized countries and the majority of developing countries. Development of the capital goods industry was seen as a long term process requiring mastery of a wide range of technologies. Newcomers into the sector faced several barriers ranging from prejudices on the part of foreign trained technical personnel preferring to purchase industrial machinery from industrialized countries, to problems of limited domestic markets and lack of economic and technical infrastructure. The need to formulate integrated development plans for the sector that took into account the technological complexity of capital goods and a country's manufacturing capacity was recognized by the Consultations.

2. Among the large variety of capital goods, machine tools occupy a special position since they are used to manufacture other capital goods. This strategic importance has not always been recognized by developing countries and very few machine-tool plants are found in these countries. Machine tools have undergone major technological changes in recent years, exemplified by the advent of CNC machine tools and flexible manufacturing systems. These developments have direct implications on engineering industries world-wide, and affect both users and producers of machine tools.

I. THE WORLD MACHINE-TOOL INDUSTRY: HOW IT FUNCTIONS

3. With world-wide sales estimated at $ 46,500 1/ million in 1990, the machine-tool industry is small compared to other industrial sectors. Despite its small size, the machine-tool industry plays a strategic role in economic and industrial development. Machine tools are capital goods used to manufacture other capital goods which provide the means of production in all manufacturing activities. The strategic nature of the industry arises from its role as a supplier of continously improved manufacturing technologies, (machines, systems and methods) which is a major factor in the enhancement of overall productivity in industry. The machine-tool industry forms one of the principal nodes 2/ of technological diffusion since new skills and techniques developed in the industry, in response to specific requirements, rapidly diffuse into other manufacturing industries.

4. The machine-tool industry is an established industrial sector which has provided the driving power for industrial development for well over a century. The industry is knowledge-intensive, employing highly skilled design engineers, production technologists and machine operators. It is, however,

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1/ American Machinist, February 1991.
2/ OECD, "Technology and international Competitiveness: an interpretation of the relationships in the machine-tool industry", 1984.

not a high-technology industry. Investments in R&D are relatively low compared to other industrial sectors like semiconductors, computers and pharmaceuticals. The industry uses many technological innovations developed in other industries, notably electronics and increasingly materials science.

5. A distinction is made between metalcutting and metalforming machine tools.* On a world-wide basis, metalcutting machine tools account for about 75 per cent of the market demand the remaining 25 per cent being for metalforming machine tools. Machine tools were primarily manually-operated up to the early 1970s. The invention of the microprocessor led to the development of CNC machine tools. This development altered the "boundaries" of the machine-tool industry. Prior to the introduction of CNC technology, the machine-tool industry was a clear sub-sector of the non-electrical machinery industry (ISIC 382). The machine-tool industry can now be considered as a subsector of the mechatronics sector, which is a combination of mechanical engineering and electronics. 3/

6. There are some 3000 types of machine tools differing in their production technologies and design features. This diversity has made it necessary for machine-tool firms to specialize in well-defined, narrow product lines catering for particular markets. One study 4/ has identified about 100 strategically different machine-tool business segments differentiated according to:

(a) degree of specialization of the machine tool: a conventional lathe has universal application while some machine tools are tailor made for a specific application;

(b) production volume: a machining centre is well adapted to the production of small batches of differentiated products while transfer lines are used in large volume production; and

(c) market potential: larger firms producing for large markets will have a competitive advantage over smaller firms.

7. The machine-tool industry is dominated by small- and medium-sized enterprises, especially in the industrialized market economies. The industry has been ideal for entrepreneurial engineers and machinists who have established production units on the basis of skills rather than heavy financial resources. However, these producers buy-in many components and rely heavily on sub-contractors. The value of bought-in components and subcontracting services, as a percentage of total production inputs, typically ranges from 40 per cent in Europe to 60 per cent in Japan. This heavy reliance on subcontracting services has led to geographical concentrations of the industry.

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* Only metalworking machine tools are considered.

3/ Mick McLean, "Mechatronics development in Japan and Europe," Frances Pinter, 1983.

4/ Boston Consulting Group, "Strategic study of the machine-tool industry,", 1985.

8. The high level of subcontracting arrangements in Japan has had distinct advantages, including higher efficiencies measured in terms of output per employee as compared to other countries, with lesser use of subcontractors. The machine-tool builders in Japan are mainly involved in assembly of bought-in components, wiring and final adjustments. Production is limited to the most important pieces, such as spindles and sometimes heavy castings. All other components, including ball bearings, electric motors, cables and electronic controls are purchased from subcontractors. In addition, subcontractors provide services such as heat treatment, casting, surface treatment, gear-making and machining.

9. Among the determinants for competitive advantage of a national machine-tool industry, the following appear most important:

(a) Factor conditions: the industry relies on highly skilled labour in mechanical engineering and increasingly electronics. Thus availability of such skilled personnel is one of the most important factors contributing to success in the machine-tool industry.

(b) Demand conditions: the characteristics of the domestic and regional demand for machine tools determines the growth and technological level of the machine-tool industry. Thus, the structure, size, and technological level of the engineering industries play a crucial role in shaping the machine-tool industry. Among engineering industries, the automotive and aerospace industries often have the most stringent requirements and hence their presence tends to stimulate technological innovations in the machine-tool industry.

(c) Supporting industries: the presence of a subcontracting network of supporting industries is important for development of the machine-tool industry.

(d) Firm strategy, structure and competition: larger firms have advantages for those market segments which allow long runs of production. Smaller firms tend to concentrate in niche markets. In all cases, a competitive environment is essential for success.

10. Government policies and measures directly contribute to shaping the competitive advantage of a national machine-tool industry. Thus, by providing appropriate training facilities, the factor conditions are promoted. Governments can shape demand conditions through public procurement policies and establishment of standards and regulations. Governments may also take measures for the promotion of supporting industries and for influencing firm strategies through tax and trade policies.

11. World production of machine tools in dollars has increased from $8,000 million in 1968 to $46,500 million in 1990. The increase has, however, not been uniform over this period. In fact, machine-tool production is considerably more cyclical than that for other industrial sectors. The demand

for machine tools is strongly linked to the demand for capital goods which are themselves dependent on investment trends. It has been observed that in periods when production capacities were fully utilized, a 10 per cent variation in the demand for consumer goods brought about a 40 per cent variation in the demand for capital goods. 5/

12. Table 1 depicts the geographical distribution of machine-tool production for the years 1980, 1985 and 1989 on a regional basis. Western Europe retained the leading position over this period. The biggest changes occurred in both North America, where the share of world production dropped from 18.7% in 1980 to 8.7% in 1989 and in Asia, where the corresponding figures show an increase from 17.9% to 30.3%. The latter case is mainly due to the rise of Japan and some East Asian countries.

13. Table 2 lists the main machine-tool producing countries in 1990 and their estimated shares of the world market. Machine-tool production is heavily concentrated among a few industrialized countries. The 1990 top five producers were Japan, Germany (former FRG), USSR, Italy and Switzerland. These five countries accounted for 67 per cent of world production for that year. This concentration of production is, however, lower than that for related industries, such as those for electronics and automotive. In the electronics industry, the top five producers accounted for 79 per cent of world production in 1988. For the automotive industry, the corresponding figure was 76 per cent.

14. Significant shifts in production have occurred among the leading producers in industrialized countries. Among factors which have contributed to the declining performance of the machine-tool industry in some of these countries, the following may be cited:

(a) lack of export orientation;

(b) domestic demand conditions that did not stimulate technological innovations;

(c) reluctance on the part of producers to adopt new innovations;

(d) poor relationships between local producers and users of machine tools. In particular, some main producers failed to appreciate the changing needs of small- and medium-scale engineering enterprises;

(e) lack of interface standards between numerical control units from different vendors.

5/ B. Real, "Technical Change and Economic Policy - The Machine-Tool Industry", OECD, 1980.

15. On the other hand, countries which increased their shares of world production of machine tools had positive atributes with regard to the above factors and their industries were characterized by:

(a) shop-floor work organizations which emphasized flexibility in production even prior to the introduction of flexible automation technologies;

(b) investments by major users in the production of machine tools for their captive needs as well as external sales. Strong user-producer bonds were thus forged;

(c) pre-eminence in the art of precision machining and production of electronics products;

(d) industrial policies which recognized the strategic importance of the machine-tool industry and hence gave the necessary incentives for entrepreneurs to enter the sector.

16. Consumption of machine tools is a rough indicator of a country's rate of industrialization. In 1988, western industrialized countries accounted for 63 per cent of world machine-tool consumption. The corresponding share for the USSR and Eastern Europe was 28 per cent, while that for developing countries stood at 9 per cent.

17. There is a strong correlation between machine-tool consumption and investment trends in the engineering industries where there is a need for modernization and/or creation of additional capacities. With the increasing use of CNC machine tools, software costs represent an increasing share of consumption in the industry.

18. In 1968, one-third of machine tools produced world-wide were traded internationally. Twenty years later, this ratio had reached almost 50 per cent. This trend points to the fact that international trade plays a very important role in the machine-tool industry. The machine-tool industry has become globalized and success in the industry requires effective exporting in the international market. In fact, trade ratios (defined as the ratio of the sum of imports and exports to production) can be as high as 300 per cent for some producers. This implies a high level of import penetration. The combination of export orientation and import penetration is further testimony to the high degree of market specialization in this industry.

19. Exports to developing countries rose from US$ 2515 million in 1980 to US$3453 million in 1987. Western Europe is the largest supplier of machine tools to developing countries, accounting for 46 per cent of all machine-tool imports by developing countries in 1987.

20. In contrast to the high trade orientation, the internationalization of capital in the machine-tool industry has been very limited, with most foreign investments being made in industrialized countries. Thus, leading American and European machine-tool firms have invested mainly in each other's region.

Overseas production by Japanese machine-tool manufacturers has been a competitive strategy in keeping with the export drive measures adopted by that country. Japan has set up machine-tool plants in the U.S.A. and Europe to cater for the needs of, inter alia, their own newly installed automotive plants in those countries.

21. Foreign investments in developing countries have been limited to a few cases in Latin America and Asia. Germany (former FRG) has been a forerunner in establishing joint venture firms in Latin America, while some Japanese firms have relocated their production of conventional machine tools to other Asian countries.

II. MACHINE-TOOL PRODUCTION IN DEVELOPING COUNTRIES

22. The share of developing countries in production of machine tools is very limited. In 1988 this share stood at only 9 per cent 6/. It is possible to distinguish four categories of developing countries with regard to the status of the machine-tool industry in those countries:

(a) countries with little or no manufacturing capacity for machine tools;

(b) countries with the capability to manufacture machine tools but which have not yet entered the sector;

(c) countries manufacturing conventional machine tools and planning to enter into production of NC machine tools; and

(d) countries that produce conventional and NC machine tools and aspire to consolidate their positions.

23. One fundamental pre-requisite for successful entry into the machine-tool industry is the presence of dynamic engineering industries. Engineering industries are important for two main reasons: on the demand side, they constitute the major market for machine tools, and on the supply side, they provide the necessary supporting industries, which facilitate subcontracting arrangements in the production of machine tools. However, the structure of engineering industries is also important. In countries with little or no manufacturing capacity for machine tools, the engineering industries are embryonic and consist mainly of manufacturers of metal products (ISIC Division 381). Fabrication of most metal products requires mainly simple metalforming machine tools, drills and grinders. In these countries, metalcutting machine tools are used primarily in repair and maintenance workshops and for educational purposes. Establishment of machine-tool production facilities may not be feasible except for some countries where production of simple drills and grinders may be initiated depending on other factor conditions.

6/ World Machine-Tool Industry (UNIDO ID/WG.514/), 1991.

24. In the more advanced developing countries, engineering industries are often more developed and, in some cases, may include production of non-electrical machinery (ISIC Division 382) and transport equipment (ISIC Division 384). In these same countries it may be possible to sustain a viable machine-tool industry. Table 3 presents data on the production output (and structure) of engineering industries and machine-tool production in selected developing countries. Analysis of this data shows that machine tool production takes place mainly in those countries with value-added production of their engineering industries in excess of US$1000 million. Some production is however also registered in a few developing countries with much smaller value-added outputs of their engineering industries. In some of these latter group of countries, regional or sub-regional markets may justify existence of machine-tool plants.

III. CONSTRAINTS AND OPPORTUNITES FOR THE DEVELOPMENT OF THE MACHINE-TOOL INDUSTRY IN DEVELOPING COUNTRIES

25. Increased participation of developing countries in machine tools production has to take into account, not only of the strategic nature of the industry, but also the anticipated economic returns (in terms of value-added, foreign exchange savings, employment generation and domestic resource costs), as well as the prospects of being internationally competitive within a reasonably short period of gestation.

26. Entry into the industry should also be based on a comprehensive evaluation of the economic and technical constraints that are likely to be faced. Appropriate strategies to resolve those constraints should then be developed. Among the factors that often act as barriers to entry into the machine-tool industry and sustenance of competitive production, the following should be recognized:

(a) Lack of sufficient domestic market. The domestic market for machine tools is directly related to the state of development of engineering industries, including their sub-sectoral structure and sophistication. Major users of machine tools are the non-electrical machinery, transport equipment and electrical machinery sub-sectors. However a large domestic market may offer only static efficiency to the machine-tool industry. The quality of this domestic demand is equally important in creating dynamic efficiencies by exerting pressure on producers to upgrade their production lines. It should also be pointed out that, while the domestic market for many developing countries may be too limited, there are often unexploited opportunities in sub-regional and regional markets. Through co-operation it is possible to develop viable machine-tool production facilities to serve sub-regional and regional markets. Important initiatives that have been taken in this respect include the capital goods integration agreement between Argentina and Brazil and the agreement to promote joint projects between Morocco and Tunisia. Furthermore, the trend towards specialization in the production of NC machine tools in the

industrialized countries offers new export market opportunities for conventional machine tools that could be exploited by those developing countries able to attain international competitiveness in that market niche.

(b) Shortage of skilled personnel. The machine-tool industry requires engineers, technicians and skilled machine operators specialized and having acquired several years experience in the metalworking and engineering industries. Such highly qualified personnel are not easily found in developing countries. A human resource development programme, coupled with an integrated strategy to develop the metalworking and engineering industries, could alleviate this constraint. In this respect, it may be useful to define clearly the role of the State vis-a-vis the private sector.

(c) Lack of supporting industries. As already established, the machine-tool industry functions most efficiently where it is served by a well-developed network of subcontractors. These subcontractors provide parts and components as well as some technical services to the machine-tool producers. Due to the underdevelopment of engineering industries in several developing countries, subcontracting firms are not easily found and this has led to the tendency to establish highly vertically integrated machine-tool plants. This situation has led to inefficient plant utilization and high prices of products in some of these countries.

(d) Difficulties in technology acquisition. Historically, the main channel for technology transfer in the machine-tool industry has been "reverse engineering", while formal technology transfer agreements have played a far smaller role. This non-formal channel of technology transfer has been widely used in the U.S.A., Japan, and more recently in some East Asian countries. Reverse engineering involves learning by using imported machine tools and developing replicas or adapted models. The lack of access to blueprints makes reverse engineering very difficult, a problem which puts many developing countries at a disadvantage due to their shortage of skilled personnel in the engineering sector. Thus for these developing countries, technology acquisition will be based mainly on the formal channel involving licensing and/or joint ventures. Successful transfer of technology under these arrangements requires a long step-by-step process of backward progression from sales, servicing, licensing for assembly of completely knocked-down kits and then to licensing for full production. Since the design aspect is crucial in this industry, licensing arrangements should reflect this priority as well as the production know-how so as to ensure effective technology transfer.

(e) Product mix restriction and need to diversify. The product mix is determined by the nature of the domestic market. In most developing countries conventional machine tools will remain the most widely used machine tools in the foreseeable future. Also, since producers in the industrialized countries are shifting towards NC machine

tools, this opens up new export opportunities for developing countries. Thus the product mix for new entrants will be of the conventional type. As a guideline, Table 4 categorizes some examples of different types of machine tools in relation to the level of manufacturing capabilities in a given country. Usually newcomers start with simple standard equipment like bench drills, bench grinders and sheet metal forming machines and gradually progress with the introduction of the more sophisticated equipment. It is not advisable, neither is it desirable, to attempt to be self-sufficient in this industry. However, product diversification to include other products of engineering industries (such as agricultural machinery), is often sound business practice due to the cyclic nature of the machine-tool market. For the more advanced developing countries, entry into NC machine-tools production may be viable depending on the strength of their precision mechanics and electronics industries. While NC controls may be imported, it is necessary to develop skills in software production and system integration as well for effective production and use of NC machine tools.

(f) Inadequate industrial policies. Industrial policies have played a significant role in the development of the machine-tool industry in the industrialized countries through fiscal incentives, local protection from imports, State procurement policies, and financial support for research and development. Such comprehensive industrial policies are often lacking in the developing countries. This situation is aggravated by the increasing trend towards imports liberalization which could jeopardize newly established machine-tool plants. Fiscal incentives to encourage local production could help to sustain machine-tool plants operating under an imports liberalized economy. Where protection is offered, this should take into account the need to encourage competitiveness so that the local engineering industries do not suffer undue disadvantages arising from inefficiencies of the machine-tool industry. Governments could also play the important role of mediating between the sometimes conflicting interests of users looking for the best equipment available at the lowest price, and those of machine-tool producers endeavouring to upgrade local production. Close collaboration in product development is essential between users and producers so as to ensure that the machine-tool industry adequately meets the technological requirements of the user industries. The establishment of government-funded engineering design and development institutes to assist producers and users, has been an important motivation for the development of machine-tool industries in several countries.

IV. UTILIZATION OF ADVANCED MACHINE-TOOL TECHNOLOGIES

A. Numerical Control Machine Tools

27. All countries utilize machine tools either for repair and maintenance or engineering production. Hence technological developments affecting machine tools are of concern to all countries. The most fundamental innovation which has occurred in the machine-tool industry, has been the application of microelectronics technologies in the development of numerical control systems. This innovation has led to the realization and rapidly increasing utilization of flexible automation equipment such as CNC machine tools, flexible manufacturing cells and flexible manufacturing systems. The underlying feature of these technologies is the greater degree of flexibility in production than was the case for classical electro-mechanical automation based on exploitation of economies of scale.

28. Flexible automation allows a new compromise between flexibility and economies of scale. While economies of scale were gained because the cost of producing a single unit declined as volume of production increased, economies of scope are gained in the volume production of a set of differentiated goods 7/ and they are created by standardizing processes to manufacture a variety of products. Economies of scope are said to exist when a firm which produces two products simultaneously is able to produce them at a lower cost than two separate firms producing each one of these products separately.

29. Compared to mass production systems, flexible automation equipment offers greater flexibility in terms of:

(a) accepted variance of throughputs (defined as the number of cost-effectively produced homogeneous items per unit of time);

(b) acceptable variances in output varieties; and

(c) minimum scale of production.

30. The trend towards more flexible production systems has also to be considered in the context of changes affecting market demand. In the period of relative scarcities following the Second World War, price was the most important criterion for consumer products and enterprises mass-produced goods looking for the cheapest labour costs. In the 1970s, quality became a criterion as important as price, and in the 1980s consumers demanded quality products which were simultaneously more tailored to their individual tastes and needs. With these changes in the market place, the era for mass production systems appears to be giving way to that for flexible production systems.

7/ J.D. Goldhar, M. Jelineks "Plan for economies of scope", Harvard Business Review 61, Nov-Dec, 1983, page 141.

31. This demand pressure which was first felt in the consumer electronics market and subsequently in the automotive industry, has accelerated the pace of development of flexible automation equipment. Corporations which produced customized goods aimed at market niches, had to be flexible enough to increase production in those market segments in which demand proved high. These corporations needed equipment which could produce economically in small batches in order to reduce work in progress, minimize inventories and allow consumer demand to be met in the shortest possible period. In some markets, there is a growing "time-based competition" among manufacturers since consumers are willing to pay more for the privilege of speed.

32. The consequences of these changes go beyond a retooling of manufacturing facilities since a significant level of flexibility can often be achieved through organizational innovations. In order to face up to these new challenges, manufacturing companies, especially in Japan and increasingly in the other industrialized countries, are reorganizing their production processes under just-in-time (JIT) principles. JIT has evolved into an overall system for eliminating waste and maintaining high levels of reliability and quality in the total production process.

B. Social impact of flexible automation

33. The social impact of flexible automation technologies relates to employment, work intensification, work organization and job contents.

34. With regard to employment, flexible automation technologies generally save on labour. As an example, it has been estimated that a CNC machining centre with a robot and tool management system required only one or two operators. A comparable arrangement using conventional machine tools would require 10 or more operators.

35. Despite the labour saving characteristic of flexible automation technologies, it is necessary to consider both direct and indirect effects so as to assess the overall impact on employment. Direct effects include employment lost or generated inside or outside the enterprise. Indirect effects refer to the gains obtained due to the competitiveness acquired or the employment which could have been lost on account of lack of competitiveness caused by failure to adopt new technologies.

36. At the macroeconomic level, studies in industrialized countries have revealed no significant correlation between unemployment rates and the use of flexible automation techniques. Investments in flexible automation equipment have not led to significant job displacements since against this reduction, there is the additional demand for indirect support in areas such as maintenance, production planning and computer programming.

37. Introduction of flexible automation equipment leads to work intensification. When conventional machine tools are used the effective time for machine utilization is, on average, only about 5-6 per cent of the total time spent on a work piece. The rest of the time the machine is idle because

of placement, measurement, unloading, tool change, etc. With numerical control machine tools, the effective time for machine utilization is typically 15 to 25 per cent.

38. New work organisations are required when flexible automation equipment replaces conventional machine tools. With the latter, work organization is characterized with relative separation between production planning activities and those of the workshop. Use of NC machine tools necessitates greater interaction between the production planning function and workshop activities. Thus, the traditional work separation between production planning and workshop activities tends to disappear when flexible automation equipment is used.

39. The impact of flexible automation technologies on workers' skills is still a subject of debate. It has been argued that these technologies are fundamentally de-skilling since they substitute for intellectual activity, judgement and experience. On the other hand, opponents to the de-skilling thesis stress the positive impact of automation on workers skills. It is, however, generally agreed that these new technologies do not generate employment for low-skilled workers.

40. Flexible automation technologies change the nature of the workers skills in two ways. Firstly, the know-how of the skilled worker is partially "memorized" upstream from production. Secondly, the functions of execution and command tend to be transferred to the machine itself.

41. Transformation of workers' skills as a result of the introduction of CNC machine tools appears outside the workshop as well. This is particularly so for maintenance technicians for whom knowledge of microelectronics technologies becomes an absolute necessity.

C. Sectoral diffusion of NC machine tools

42. The trend towards use of flexible automation technologies in engineering industries can be deduced by analysing the sub-sectoral diffusion of NC machine tools (including CNC). This analysis would indicate which sub-sectors have had the highest diffusions and hence the biggest changes on rules of international competitiveness.

43. The diffusion of NC technologies can be determined from inventory statistics of leading machine-tool users. Analysis of these inventories reveals that:

(a) there is an accelerated pace of acquisition of NC machine tools by small and medium scale enterprises. The advent of highly "user friendly" manual data input NC machine tools and off-line programming systems have made this technology much more attractive to smaller engineering firms;

(b) the greatest number of NC machine tools is found in the non-electrical machinery sub-sector (ISIC 382). However the rate of

diffusion has been highest in the transport equipment sub-sector. The diffusion rate has also been increasing in the electrical machinery sub-sector;

(c) projections on the population of NC machine tools in engineering industries show that the rates of diffusion will continue to increase for most of the 1990s.

D. Flexible Manufacturing Systems and Com,uter Integrated Manufacturing

44. NC machine tools are essentially substitution innovations which offer more efficient ways of doing what can be done by conventional machine tools. Flexible Manufacturing Systems (FMS) represent revolutionary innovations with potential gains that are considerably greater than those attainable with stand-alone NC machine tools.

45. Due to the variety of definitions and inadequate data, estimates of installed FMS vary widely. Diffusion of FMS has, however, been restricted to selected industries: mainly transport equipment, non-electrical machinery and electrical machinery, in that order.

46. When successfully implemented FMS can dramatically reduce production costs as a result of increased machine utilization, reduction in set-up and lead times and savings in stocks, work in progress, capital employed and labour costs. Investments in FMS have, however, not always yielded the anticipated results due to:

(a) technical problems in terms of interface software and network organization;

(b) organizational problems; and

(c) problem diagnosis difficulties due to the integrated nature of the system.

47. As a consequence of the above difficulties, many firms have opted for a step-by-step approach whereby small islands of automation are progressively linked with workpiece transport and tool management systems.

48. Whilst NC machine tools and flexible manufacturing systems are confined to the manufacturing sphere, computer integrated manufacturing (CIM) concerns the integration between design, production and management. The CIM concept will be further exploited in the 1990s to yield integrated business systems.

49. One major constraints on the diffusion of CIM is the lack of industry-wide standards in software. The International Standards Organization is promoting the Open Systems Interconnection (OSI).

V. FINANCING MECHANISMS FOR CAPITAL GOODS INDUSTRY DEVELOPMENT

50. Financing is one of the major constraints hindering capital goods (including machine tools) development in developing countries. Many of these countries are experiencing acute shortages of financing for new production facilities, modernization projects and trade development. This situation arose from the consequences of the excessive debt burdens and economic crises faced by several developing countries. Financing problems are especially severe for small- and medium-sized enterprises that often cannot satisfy loan conditions imposed by financial institutions.

51. Leasing agreements in the capital goods sector in developing countries could play a far greater role than hitherto and hence help to alleviate part of the problem. This is particularly so because guarantees are not normally required under a leasing contract as would be the case for commercial loans.

52. In the industrialized countries leasing is a multibillion dollar industry. As an example, at the end of 1989, nearly 30 per cent of the gross capital formation in the United States of America was financed through leasing. This translated to the sum of $120,000 million.

53. Leasing firms are often affiliated with financial institutions, machinery suppliers or marketing concerns. The firms enter into leasing contracts with user enterprises which give the latter the right to use the machinery in their production activities for a specified period without undertaking to purchase. The user enterprise (the lessee) pays a periodic fee to the leasing firm (the lessor) during the contract period. At the end of the contract period, the lessee usually has three options, namely:

(i) to purchase the machinery at a residual value specified in the contract; or

(ii) to extend or renew the leasing contract; or

(iii) to let the contract expire with no further obligations.

54. Although there is a wide variety of leasing contracts, it is possible to classify them into three basic types. These are operational leasing, financial leasing and sale lease-back.

55. Operational leasing contracts are designed to cover a period which is less than the average useful life of the machinery. The average useful life of machinery has been defined in some countries as that for which the present values of all periodic payments would equal to 75 per cent of the cost of the machinery, i.e. the current residual value represents 25 per cent of the original cost. This type of contract is common when the lessee has only a temporary need for the machinery or when it is not possible to specify exactly for how long the machinery will be required. Operational leasing is usually accompanied with a complete service contract.

56. Under a financial leasing contract, the lessee may use the machinery for the entire average useful life. The machinery is frequently tailored for the specific requirements of the lessee. The lessee often specifies the supplier although it is the lessor who acquires the machinery. Financial leasing contracts may also be accompanied by service contracts although the coverage of this contract will be more limited to reflect the degree of specialization of the machinery. Financial leasing contracts bear many similarities to loan agreements and this fact has sometimes given rise to legal problems and resulted in substantial differences with regard to tax deductions.

57. Sale lease-back contracts involve two elements:

(a) the leasing firm acquires used machinery from a manufacturing enterprise;

(b) the leasing firm leases the machinery back to the same manufacturing enterprise.

The interesting feature of sale lease-back contracts is that the machinery never physically leaves the lessee's factory, but is only reflected in the balance sheet. This arrangement is particularly attractive to enterprises that need to increase their working capital and/or reduce their level of indebtedness. The arrangement may also be used to finance modernization projects while continuing to use the old machinery for a temporary period.

58. Leasing arrangements can only function when an appropriate legal framework has been determined. Among the legal issues to be specified are:

(a) laws governing the establishment and operation of local and foreign leasing firms;

(b) laws defining the rights of the lessee in case of bankruptcy of the lessor;

(c) laws defining the rights of the lessor in cases of bankruptcy or non-payment of fees by the lessee; and

(d) tax laws and customs regulations relating to leasing arrangements.

VI. ENVIRONMENTAL IMPACT

59. The machine-tool and supporting engineering industries involve industrial processes that could have adverse impacts on the environment if adequate precautions are not taken. These processes are of 4 types, namely:

(a) mechanical: e.g. sandblasting, grinding, finishing and polishing;

(b) chemical: e.g. through solvent cleaning, acid pickling, salt bath hot cleaning and quenching, conversion coating and electroless plating technology;

(c) physical: e.g. powder coating and dipping; and

(d) electrolytic: e.g. electro cleaning, electro polishing, anodising and eletroplating.

60. The potential health hazards and other negative effects on the environment that may arise from pollutants released by the above industrial processes are well documented. Exposure pathways for these pollutants include direct contact inside and outside the plant as well as through effluent discharges. The latter may lead to disastrous effects if discharged directly into water. Even discharges into sewage systems may affect the operation of monitoring equipment and pumps for these systems. Thus waste control and management is an important consideration in all engineering industries, including the machine-tool industry.

61. A basic requirement for industrial waste control and management is to understand what is happening. This involves use of monitoring equipment to measure concentrations of solvents, acids and effluents as well as carrying out waste audits. Depending on the results of this analysis, action programmes to minimise adverse environmental impacts may involve some or all of the following elements.

(a) more efficient housekeeping: a major consideration here is waste water which is one of the main sources of pollution in this industry. Water conservation may be achieved through flow rate adjustments to minimum requirements and recycling of rinse water;

(b) process modifications to reduce environmental impact: e.g. through solvent substitution and detoxification of effluents before discharging;

(c) resource recovery and recycling; and

(d) use of cleaner production technologies.

62. A regulatory mechanism is essential for environmental management. While laws and regulations for environmental protection are necessary, these are not sufficient on their own. Additional factors to promote cleaner industrial production include public awareness and training, and government funding of R&D in cleaner technologies and demonstration projects. Transnational corporations may also play a major role by ensuring that the same environmental standards are maintained in all their facilities world-wide including those in developing countries.

VII. FINAL CONSIDERATIONS

63. Newcomers into the machine-tool industry have to confront the pertinent conditions of entry into the sector. Having embarked on production activities it is necessary to adopt certain measures to sustain competitiveness and ensure internal dynamism. Effectively utilized, machine tools can make a major contribution to the development of engineering industries including

provision of repair and maintenance services, production of spare parts for industrial machinery, and inculcating an industrial tradition through imparting requisite skills and attitudes towards manufacturing. Flexible automation technologies offer new opportunities for the more advanced developing countries. The main points to be considered in such a programme include:

(a) Industrial policies: what incentives should be provided to local machine-tool and other capital goods producers to enable them to sustain production while countries simultaneously pursue import liberalization policies? What policies should be adopted vis-a-vis importation of second-hand capital goods including machine tools?

(b) Financing: what are the prospects for enhancing leasing practices in the capital goods sector in developing countries? If leasing is to be promoted, what general parameters for legal frameworks should be adopted for foreign and local leasing firms? How should these leasing firms relate to other financial institutions including commercial banks? What tax provisions and customs regulations are required to sustain leasing arrangements at the national, regional and international levels? What role should regional and international trade and development banks play in promoting leasing practices? How can small- and medium-sized engineering firms be assisted to secure financing more readily from financial institutions? What are the prospects of using debt conversion schemes in alleviating the financing problems of the industry in developing countries?

(c) Entrepreneurial policies and marketing strategies: how can the private sector be encouraged to play a larger role in the engineering industries that are crucial for providing essential subcontracting services to the machine-tool industry? What specific entrepreneurial policies should be promoted to encourage private sector investments in engineering industries? What kind of inter-company relationships should be encouraged between the machine-tool builders and subcontractors? Since the main markets for machine tools are the engineering industries, what measures should be taken to ensure stable development of these industries? Also, considering that market specialisation is an absolute necessity in this industry, what specific proposals could be made to enhance South-South and North-South trade in machine tools?

(d) Human resources development: what additional impetus should be given to formal education and on-the-job training in mechanical and electronics engineering? This should cover the complete spectrum of skilled technical personnel encompassing design engineers, production planners, machine setters, machine operators, maintenance technicians and software specialists. How can licensing agreements be strengthened to ensure that local personnel are adequately trained? What incentives should be provided to attract and retain skilled workers who may be tempted to leave the industry due to fear

of periodic layoffs necessitated by widely fluctuating business cycles? What specific programmes should be promoted to enhance capacities in precision mechanics?

(e) Acquisition and promotion of technology: what are the prospects for reverse engineering in developing countries? What action should countries take to strengthen their innovative capacities? What are the implications on patent restrictions, bearing in mind many leading producers extensively utilized the reverse engineering route in building up their own national capacities? How can a greater flow of conventional machine-tool technologies and flexible automation technologies be effected on a North-South and South-South basis?

(f) Production complementarities and regional co-operation: what are the major impediments in promoting production complimentarities at the regional level and how could these be overcome? What should be the main elements of a co-operation agreement among countries participating in a programme for production complimentarities in capital goods including machine tools?

(g) Industrial re-organization: how can developing countries prepare themselves for the imminent era of flexible production systems? What industrial reorganization could be implemented even prior to the introduction of flexible automation technologies? Are Just-in-Time principles appropriate for developing countries?

(h) User-producer relations: what should be done to ensure greater interaction between users and producers of machine tools? What institutional mechanisms are required? What role should engineering design and manufacturing technology institutes play in enhancing user-producer relations? What role should the government play?

(i) Environmental considerations: what specific assistance should be given to developing countries to enable them to control the environmental impact of the engineering industries more effectively?

Table 1: Geographical Distribution of Machine-Tool Production according to Regions (in millions $)

Region	1980	1985	1989
North America	5043 (18.7%)	2878 (13.1%)	3659 (8.7%)
Western Europe	10869 (40.3%)	7228 (32.9%)	16276 (38.7%)
Eastern Europe and the USSR	5475 (20.3%)	4811 (21.9%)	8201 (19.5%)
Latin America	378 (1.4%)	286 (1.3%)	505 (1.2%)
Asia	4828 (17.9%)	6327 (28.8%)	12743 (30.3%)
Others	378 (1.4%)	439 (2.0%)	673 (1.6%)
World	26971 (100%)	21969 (100%)	42057 (100%)

Source: American Machinist (different issues).

Table 2: Main machine-tool producers in 1990 (in $ millions)

	Country	1990 Production	Share (%)
1.	Japan	10,832.1	23.25
2.	Germany (former FRG)	8,826.5	18.95
3.	USSR	4,580.0	9.83
4.	Italy	3,966.0	8.51
5.	Switzerland	3,183.6	6.83
6.	U.S.A.	3,140.0	6.74
7.	United Kingdom	1,719.7	3.69
8.	France	1,364.8	2.93
9.	Former GDR	1,085.0	2.33
10.	Taiwan, Province of China	1,034.9	2.22
11.	Spain	1,034.9	2.22
12.	People's Republic of China	989.7	2.12
13.	Republic of Korea	733.3	1.58
14.	Yugoslavia	629.0	1.35
15.	Romania	530.7	1.14
16.	Brazil	450.0	0.97
17.	Canada	368.9	0.79
18.	Austria	280.5	0.60
19.	Belgium	271.9	0.58
20.	Sweden	251.7	0.54
21.	India	243.5	0.52
22.	Poland	200.0	0.43
23.	Czechoslovakia	191.9	0.41
24.	Bulgaria	160.0	0.35
25.	Hungary	97.8	0.21
26.	Netherlands	97.8	0.21
27.	Denmark	80.3	0.17
28.	Singapore	65.7	0.14
29.	Finland	57.8	0.13
30.	Argentina	38.2	0.08
31.	Others	76.3	0.16
	TOTAL	46,582.5	100.00

Source: American Machinist, February 1991.

Table 3: Engineering industries value-added production (and subsectoral structure) and machine-tool production (in $ millions)

	Value added 1987	Sub-sectoral structure					Machine-Tool Production 1989
		381	382	383	384	385	
People's Republic of China	22000	N/A	N/A	N/A	N/A	N/A	832
Brazil	20932	17%	30%	25%	26%	2%	449
Taiwan, Province of China	10989	16%	14%	51%	15%	3%	695
Yugoslavia	8378	28%	23%	26%	21%	2%	671
Republic of Korea	8219	18%	20%	53%	39%	4%	597
Argentina	5897	30%	17%	15%	37%	2%	38
India	5882	9%	30%	29%	29%	3%	272
Mexico	5630	23%	18%	20%	33%	5%	18
Iran	3696	21%	22%	29%	44%	2%	p*
Singapore	3062	11%	14%	56%	16%	3%	37
Hong Kong	2557	20%	12%	46%	6%	16%	1.50
Nigeria	1825	24%	5%	8%	63%	0%	
Venezuela	1735	32%	16%	20%	31%	2%	
Thailand	1681	13%	16%	19%	50%	2%	
Algeria	1561	34%	21%	15%	29%	1%	18
Iraq	1366	30%	26%	42%	2%	0%	p
Egypt	1328	18%	21%	33%	27%	1%	p
Malaysia	1192	12%	10%	57%	19%	2%	p
Philippines	729	20%	9%	61%	9%	2%	
Syrian Arab Republic	715	45%	19%	30%	5%	0%	
Colombia	705	33%	11%	27%	24%	5%	
Peru	610	32%	21%	26%	19%	3%	1
Indonesia	526	34%	12%	20%	33%	0%	1
Chile	317	45%	18%	20%	16%	1%	
Pakistan	281	12%	22%	38%	27%	2%	5
Zimbabwe	220	43%	18%	28%	11%	0%	p
Ecuador	161	43%	5%	34%	13%	5%	
Tunisia	160	58%	1%	23%	18%	1%	p
Morocco	146	45%	10%	27%	16%	1%	p
Uruguay	143	29%	10%	27%	34%	1%	
Nicaragua	134	81%	3%	8%	5%	2%	
Kenya	115	23%	13%	39%	25%	0%	
Malta	79	19%	8%	48%	9%	16%	
Zambia	65	40%	14%	23%	23%	0%	

*p: Recorded production of parts and components or conventional machine tools. No detailed data available for Cuba and Democratic Republic of Korea. Sub-sectors refer to ISIC.

N/A: Not available.

Table 3 (Cont.)

Engineering industries value-added production
(and subsectoral structure) and machine-tool production
(in $ millions)

	Value added 1987	Sub-sectoral structure 381	382	383	384	385	Machine-Tool Production 1989
Bangladesh	61	20%	36%	18%	20%	7%	p
Dominican Republic	58	72%	10%	16%	0%	2%	
Cyprus	55	53%	27%	13%	7%	0%	
Bolivia	47	57%	23%	13%	4%	2%	
Senegal	46	52%	17%	4%	26%	0%	
Guatemala	39	41%	8%	36%	13%	3%	
Panama	39	59%	3%	18%	13%	8%	
El Salvador	37	30%	24%	41%	0%	5%	
Honduras	37	65%	3%	24%	8%	0%	
Sri Lanka	33	33%	24%	30%	12%	0%	
Cameroon	31	3%	68%	16%	13%	0%	
United Republic of Tanzania	31	42%	6%	10%	42%	0%	p
Jamaica	17	35%	6%	18%	41%	0%	
Ethiopia	11	91%	0%	9%	0%	0%	p

*p: Recorded production of parts and components or conventional machine tools. No detailed data available for Cuba and Democratic Republic of Korea. Sub-sectors refer to ISIC.

Source: World Machine-Tool Industry (UNIDO ID/WG.514/), 1991.

Table 4: Machine-tool manufacturers' capabilities and scope of production

LIMITED	MODERATE	SUBSTANTIAL	HIGH
Bench drills	Lathes	Turret lathes	Gear grinding machines
Bench grinders	Simple Milling	Automatic lathes	Special purpose machines
Sheet metal	Bench and Pillar	Bar and Chuck type	Transfer machines
Forming machines	Drilling machines	Tracer lathes	NC drilling machines
	Surface grinding	Precision grinding	NC boring machines
	Tool and cutter	Horizontal boring	Electro chemical machines
	Drilling machines	Jig boring	Milling machines
	Shaping machines	Gear Hobbing	
	Small Mechanical	Broaching machines	
	Presses and brakes	Radial drilling	
		Screwing machines	
		Hydraulic and mechanical presses	

Source: United Nations, The Machine-Tool Industry, 1974, page 21.